

What is claimed is:

1. A distortion correction device, comprising:

an outline extraction device extracting regular
5 graphics attached to a piece of rectangular paper from
an input image obtained by photographing the paper;

a curved-surface estimation device estimating
a three-dimensional curved-surface model of the paper
using distortion of the regular graphics as a clue;
10 and

a distortion correction device correcting the
distortion based on the three-dimensional
curved-surface model and outputting a corrected image
as an output image.
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2. A distortion correction device, comprising:

an outline extraction device extracting an
outline of a piece of rectangular paper from an input
image obtained by photographing the paper;

20 a curved-surface estimation device estimating
a three-dimensional curved-surface model of the paper
using distortion of the outline as a clue; and

a distortion correction device correcting the
distortion based on the three-dimensional
25 curved-surface model and outputting a corrected image

as an output image.

3. A distortion correction device, comprising:

an outline extraction device extracting
5 horizontal and vertical lines written in a piece of
rectangular paper from an input image obtained by
photographing the paper;

a curved-surface estimation device estimating
a three-dimensional curved-surface model of the paper
10 using distortion at an intersection of the horizontal
and vertical lines written in the paper as a clue; and

a distortion correction device correcting the
distortion based on the three-dimensional curved-
surface model and outputting a corrected image as an
15 output image.

4. A distortion correction device, comprising:

an outline extraction device extracting
horizontal and vertical character strings written in
20 a piece of rectangular paper from the input image
obtained by photographing the paper;

a curved-surface estimation device estimating
a three-dimensional curved-surface model of the paper
using distortion at an intersection of the horizontal
25 and vertical character strings written in the paper

as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

5. A distortion correction device, comprising:

an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper; and

a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

6. A distortion correction device, comprising:

a curved-surface estimation device obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

7. A distortion correction device, comprising:

an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;

5 a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and

a distortion correction device correcting distortion using distortion of the outline as a clue
10 and outputting a corrected image as an output image.

8. The distortion correction device according to claim 7, wherein the input and output images are one of a white-and-black binary image, a gradation image and
15 a color image.

9. The distortion correction device according to claim 7, wherein said outline extraction device evaluates outline likeliness indicating a ratio between both
20 series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge
25 extraction for the input image, and selects a likelier

outline pixel candidate as an outline pixel.

10. The distortion correction device according to claim 7, wherein said outline extraction device evaluates
5 outline likeliness indicating a ratio between both series of pixel strings with color of an external area of the paper and series of pixel strings with color of an internal area horizontally or vertically including a target pixel, out of outline pixel
10 candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

11. The distortion correction device according to claim
15 10, wherein said outline extraction device uses a value obtained by performing a product sum of a pixel value arbitrarily extracted from the neighborhood of the outline pixel candidate horizontally or vertically including the outline pixel candidate and
20 appropriately set fixed-value vector, as the outline likeliness.

12. The distortion correction device according to claim 11, wherein said outline extraction device uses a value
25 obtained by performing a product sum of both a

horizontally symmetrical mask $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$ and a vertically symmetrical mask $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$ arrayed horizontally and vertically, respectively, including the outline pixel candidate using k as a positive or negative constant with value 0 at a center, as the outline likeliness.

13. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses
 10 a sunken center-folded three-dimensional curved-surface model obtained by modeling sunken center-folded distortion as the three-dimensional curved-surface model.

15 14. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised center-folded three-dimensional curved-surface model obtained by modeling raised center-folded distortion as the three-dimensional
 20 curved-surface model.

15. The distortion correction device according to claim 14, wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by
 25 expressing a restriction that a horizontal or vertical

pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

16. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised circumference distortion three-dimensional curved-surface model obtained by modeling raised circumference distortion as the three-dimensional curved-surface model.

17. The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a curved-surface model obtained by applying linear Coons interpolation to a three-dimension outline model obtained by modeling a three-dimensional outline of the paper as the three-dimensional curved-surface model.

18. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses points on a three-dimensional outline as three-dimensional discrete sample points of the

three-dimensional outline model and a value corresponding to height of each of the three-dimensional sample points as a model parameter.

5 19. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a curved model with a parameter as the three-dimensional outline model.

10 20. The distortion correction device according to claim 19, wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that all curves with the same X-coordinate or Y-coordinate have the same length with
15 an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

20 21. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses values corresponding to height of two end points of a three-dimensional outline as model parameters of the three-dimensional outline model and restricts a
25 location on a condition that points on a

three-dimensional outline are on a vertical plane, including a three-dimensional line segment connecting the two end points.

5 22. The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a three-dimensional line segment as the three-dimensional outline model.

10 23. The distortion correction device according to claim 7, wherein said curved-surface estimation device estimates a three-dimensional curved surface by estimating a three-dimensional outline by perspective conversion using the extracted outline as a clue.

15 24. The distortion correction device according to claim 7, wherein said distortion correction device calculates a location in the input image, corresponding to each pixel of an image after correction using a curved coordinate system with the outline as a coordinate axis and obtains an image after correction with length of top/lower outlines and length of left/right outlines as width and height, respectively, by setting a value of a corresponding pixel in the input image as a target
20 pixel value of the image after correction.
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25. A distortion correction method, comprising:

extracting regular graphics attached to a piece
of rectangular paper from an input image obtained by
5 photographing the paper;

estimating a three-dimensional curved-surface
model of the paper using distortion of the regular
graphics as a clue; and

correcting the distortion based on the
10 three-dimensional curved-surface model and outputting
a corrected image as an output image.

26. A distortion correction method, comprising:

extracting an outline of a piece of rectangular
15 paper from an input image obtained by photographing
the paper;

estimating a three-dimensional curved-surface
model of the paper using distortion of the outline as
a clue; and

20 correcting the distortion based on the
three-dimensional curved-surface model and outputting
a corrected image as an output image.

27. A distortion correction method, comprising:

25 extracting horizontal and vertical lines written

in a piece of rectangular paper from an input image
obtained by photographing the paper;

estimating a three-dimensional curved-surface
model of the paper using distortion at an intersection
5 of the horizontal and vertical lines written in the
paper as a clue; and

correcting the distortion based on the
three-dimensional curved-surface model and outputting
a corrected image as an output image.

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28. A distortion correction method, comprising:

extracting horizontal and vertical character
strings written in a piece of rectangular paper from
the input image obtained by photographing the paper;

15 estimating a three-dimensional curved-surface
model of the paper using distortion at an intersection
of the horizontal and vertical character strings
written in the paper as a clue; and

correcting the distortion based on the
20 three-dimensional curved-surface model and outputting
a corrected image as an output image.

29. A distortion correction method, comprising:

extracting an outline of a piece of rectangular
25 paper from an input image obtained by photographing

the paper; and

correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

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30. A distortion correction method, comprising:

obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

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31. A distortion correction method, comprising:

extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline; and

correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image.

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32. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting regular graphics attached to the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

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33. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline as a clue; and

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correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

- 5 34. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

10 extracting horizontal and vertical lines written in the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical lines written in the paper as a clue; and

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correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

- 20 35. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

25 extracting horizontal and vertical character

strings written in the paper from the input image;
 estimating a three-dimensional curved-surface
 model of the paper using distortion at an intersection
 of the horizontal and vertical character strings
 5 written in the paper as a clue; and
 correcting the distortion based on the
 three-dimensional curved-surface model and outputting
 a corrected image as an output image.

10 36. A computer-readable storage medium, on which is
 recorded a program for enabling a computer to correct
 outline distortion of a piece of rectangular paper,
 included in an image obtained by photographing the paper,
 the program enabling the computer to perform:

15 extracting an outline of the paper from the input
 image; and

outputting a corrected image in which distortion
 of the outline is corrected.

20 37. A computer-readable storage medium, on which is
 recorded a program for enabling a computer to correct
 outline distortion of a piece of rectangular paper,
 included in input outline information about the paper,
 the program enabling the computer to perform:

25 estimating a three-dimensional curved-surface

model of the paper using outline distortion obtained from the outline information as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting
5 a corrected image as an output image.

38. A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper,
10 included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image;

estimating a three-dimensional curved-surface
15 model of the paper using distortion of the outline as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

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39. A distortion correction device, comprising:

outline extraction means for extracting regular graphics attached to a piece of rectangular paper from an input image obtained by photographing the paper;

25 curved-surface estimation means for estimating

a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

distortion correction means for correcting the
 5 distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

40. A propagation signal for propagating a program to
 10 a computer for correcting outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting regular graphics attached to the
 15 paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

correcting the distortion based on the three-
 20 dimension curved-surface model and outputting a corrected image as an output image.